

## Claims

1. A modulator comprising:

a PLL including a voltage-controlled oscillator, a frequency divider and a phase  
5 comparator,

said modulator generating a modulating signal based on the modulation data  
having information on a wider bandwidth than the frequency bandwidth of the PLL, setting  
the division ratio of said frequency divider by way of this modulating signal, and  
outputting a modulated carrier signal from said voltage-controlled oscillator as well as  
10 performing filtering processing by way of a pre-distortion filter on said modulation data to  
provide a frequency characteristic inverse to the frequency characteristic of said PLL in a  
process of generating said modulation signal, thereby allowing wideband modulation,

wherein said modulator comprises:

error detection means for detecting a difference between an amplitude value in a  
15 frequency equal to or below the cutoff frequency of said PLL and an amplitude value in a  
frequency higher than said cutoff frequency concerning an ac component of said  
modulating signal appearing on a control terminal of said voltage-controlled oscillator, and

frequency characteristic correction means for correcting at least one of the  
frequency characteristic of said PLL and the frequency characteristic of said pre-distortion  
20 filter in a direction said detected difference is eliminated.

2. The modulator according to claim 1, said modulator comprising a  
selector for selectively inputting, as said modulation data, first calibration data on a  
frequency equal to or below the cutoff frequency of said PLL and second calibration data  
25 on a frequency above the cutoff frequency of said PLL.

3. A modulator comprising:

a PLL including,

a voltage-controlled oscillator for outputting a modulated carrier signal,

a frequency divider for dividing the frequency of an output signal of said  
30 voltage-controlled oscillator by a modulated division ration,

a phase comparator for comparing the phase of the output signal of said

frequency divider and the phase of a reference signal and outputting the phase difference,

a charge pump for converting the output signal of said phase comparator to a voltage or a current, and

5 a loop filter for performing low-pass filtering of the output signal of said charge pump and outputting the resulting signal to said voltage-controlled oscillator;

a modulation data generator for generating and outputting modulation data having the information on a wider bandwidth than the bandwidth of said PLL;

10 a pre-distortion filter which has a characteristic inverse to the frequency characteristic of said PLL approximated and which filters said modulation data;

division ratio modulation means for modulating the output signal of said pre-distortion filter and outputting the resulting output signal as a modulating signal used to set the division ratio of said frequency divider; and

15 a pre-distortion filter frequency characteristic correction means for outputting a control signal for varying the frequency characteristic of said pre-distortion filter.

4. The modulator according to claim 3, said modulator comprising:

a calibration data generator for generating and outputting, to said pre-distortion  
20 filter, first calibration data having the frequency information on the frequency band of said PLL and second calibration data having the frequency information on the band outside the frequency band of said PLL,

wherein said pre-distortion filter frequency characteristic correction means comprises:

25 an A/D converter for converting to a digital signal the amplitude value of an ac component having the division ratio modulated by said division ratio modulation means appearing on the output of said loop filter in response to said first and second calibration data respectively;

comparison means for comparing the data of said two amplitude values output  
30 from said A/D converter and outputting the difference information; and

filter characteristic control means for varying the characteristic of said pre-distortion filter in accordance with said difference information output from said

comparison means.

5. The modulator according to claim 3, said modulator comprising:

5 a calibration data generator for generating and outputting, to said pre-distortion filter, first calibration data having the frequency information on the frequency band of said PLL and second calibration data having the frequency information on the band outside the frequency band of said PLL and

a demodulator for demodulating the output signal of said voltage-controlled oscillator,

10 wherein said pre-distortion filter frequency characteristic correction means comprises:

an A/D converter for converting to a digital signal the amplitude value of an ac component having the division ratio modulated by said division ratio modulation means appearing on the output of said loop filter in response to said first and second calibration data respectively;

15 comparison means for comparing for comparing the data of said two amplitude values output from said A/D converter and outputting the difference information; and

filter characteristic control means for varying the characteristic of said pre-distortion filter in accordance with said difference information output from said comparison means.

6. A modulator comprising:

a PLL including,

a voltage-controlled oscillator for outputting a modulated carrier signal,

25 a frequency divider for dividing the frequency of an output signal of said voltage-controlled oscillator by a modulated division ration,

a phase comparator for comparing the phase of the output signal of said frequency divider and the phase of a reference signal and outputting the phase difference,

30 a charge pump for converting the output signal of said phase comparator to a voltage or a current, and

a loop filter for performing low-pass filtering of the output signal of said

charge pump and outputting the resulting signal to said voltage-controlled oscillator;

a modulation data generator for generating and outputting modulation data having the information on a wider bandwidth than the bandwidth of said PLL;

5 a pre-distortion filter which has a characteristic inverse to the frequency characteristic of said PLL approximated and which filters said modulation data; division ratio modulation means for modulating the output signal of said pre-distortion filter and outputting the resulting output signal as a modulating signal used to set the division ratio of said frequency divider; and

10 a PLL frequency characteristic correction means for outputting a control signal for varying the current gain of said charge pump.

7. The modulator according to claim 6, said modulator comprising:

a calibration data generator for generating and outputting, to said pre-distortion  
15 filter, first calibration data having the frequency information on the frequency band of said PLL and second calibration data having the frequency information on the band outside the frequency band of said PLL,

wherein said PLL frequency characteristic correction means comprises:

an A/D converter for converting to a digital signal the amplitude value of an ac  
20 component having the division ratio modulated by said division ratio modulation means appearing on the output of said loop filter in response to said first and second calibration data respectively;

comparison means for comparing the data of said two amplitude values output from said A/D converter and outputting the difference information; and

25 charge pump current control means for varying the current gain of said charge pump in accordance with said difference information output from said comparison means.

8. The modulator according to claim 6, said modulator comprising:

a calibration data generator for generating and outputting, to said pre-distortion  
30 filter, first calibration data having the frequency information on the frequency band of said PLL and second calibration data having the frequency information on the band outside the frequency band of said PLL and

a demodulator for demodulating the output signal of said voltage-controlled oscillator,

wherein said PLL frequency characteristic correction means comprises:

an A/D converter for converting to a digital signal the amplitude value of an ac  
5 component having the division ratio modulated by said division ratio modulation means appearing on the output of said loop filter in response to said first and second calibration data respectively;

comparison means for comparing the data of said two amplitude values output from said A/D converter and outputting the difference information; and

10 charge pump current control means for varying the current gain of said charge pump in accordance with said difference information output from said comparison means.

9. The modulator according to any one of claims 3 through 5, wherein said filter characteristic control means comprises a memory for storing control data used to  
15 change the frequency characteristic of said pre-distortion filter.

10. The modulator according to any one of claims 6 through 8, wherein said charge pump current control means comprises a memory for storing control data used to change the frequency characteristic of said PLL.

20 11. The modulator according to any one of claims 3 through 10, wherein a low-pass filter is provided having a higher cutoff frequency than the bandwidth of said modulating signal between the output end of said loop filter and the input end of said voltage-controlled oscillator.

25 12. The modulator according to any one of claims 4, 5, 7 and 8 through 11, wherein said first and second calibration data have a single frequency information item.

30 13. The modulator according to any one of claims 4, 5 and 9, wherein, in said pre-distortion filter frequency characteristic correction means, said comparison means compares the amplitude values of an ac component having the division ratio modulated by said division ratio modulation means appearing on the output of said loop filter in response

to said first and second calibration data respectively, immediately after varying the output frequency of said voltage-controlled oscillator, and said filter characteristic control means varies the characteristic of said pre-distortion filter in accordance with said comparison result.

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14. The modulator according to claim 4 or 7, wherein said loop filter and said A/D converter are ac-coupled with each other.

15. The modulator according to claim 4 or 5, wherein said modulator halts  
10 the operation of said A/D converter after varying the characteristic of said pre-distortion filter.

16. The modulator according to claim 5, wherein said modulator halts the operation of said demodulator after varying the characteristic of said pre-distortion filter.

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17. The modulator according to any one of claims 3 through 16, wherein said pre-distortion filter is an IIR-type digital filter.

18. A mobile radio unit comprising the modulator according to any one of  
20 claims 1 through 17.

19. A radio base station comprising the modulator according to any one of claims 1 through 17.

25 20. A method for correcting a modulator which generates a modulating signal based on the modulation data having information on a wider bandwidth than the frequency bandwidth of the PLL, sets the division ratio of said frequency divider by way of this modulating signal, and outputs a modulated carrier signal from said voltage-controlled oscillator as well as performs filtering processing by way of a pre-distortion filter on said  
30 modulation data to provide a frequency characteristic inverse to the frequency characteristic of said PLL in a process of generating said modulation signal, thereby allowing wideband modulation,

wherein said method comprises an error detecting step of detecting a difference between an amplitude value in a frequency equal to or below the cutoff frequency of said PLL and an amplitude value in a frequency higher than said cutoff frequency concerning an ac component of said modulating signal appearing on a control terminal of said voltage-controlled oscillator, and a frequency characteristic correcting step of correcting at least one of the frequency characteristic of said PLL and the frequency characteristic of said pre-distortion filter in a direction said detected difference is eliminated.